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Canadian Forestry Service / Service canadien des forêts

1986-87

PROGRAM REVIEW

Forest Pest Management Institute

88-03576/

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Forest Pest Management Institute

1986-87

CANADIAN FORESTRY SERVICE
GOVERNMENT OF CANADA

1987

©Minister of Supply and Services Canada 1987
ISSN: 082-7461
ISBN: 0-662-15831-8
Catalogue No.: Fo41-5/1987E

Additional copies of this publication
are available free of charge from:

Information Services
Forest Pest Management Institute
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Government of Canada
1219 Queen Street East
Sault Ste. Marie, Ontario
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Cette publication est aussi disponible en français sous le titre:
Revue des Programmes, Institut pour la répression des ravageurs forestiers, 1986-87

TABLE OF CONTENTS

	Page
THE CANADIAN FORESTRY SERVICE GOVERNMENT OF CANADA	1
SERVICE CANADIEN DES FORÊTS GOUVERNEMENT DU CANADA	3
DIRECTOR'S FOREWORD	5
Microbial Control Agents	9
Bacterial Pathogens	10
Fungal Pathogens	11
Protozoan Pathogens	12
Viral Pathogens	13
Biological Interactions	15
Insect Pathogens *in vitro*	16
Cellular Interactions	17
Immunochemistry	18
Biological Systems Analysis	19
Physiological and Genetic Mechanisms	21
Pheromones	22
Insect Growth Regulators	23
Pesticide Toxicology and Efficacy	25
Insecticide Toxicology	26
Insecticide Field Efficacy	27
Plantation Pest Management	28
Herbicides Development and Use	29
Application Technology	31
Pesticide Formulations	32
Pesticide Atomization and Dispersal	33
Environmental Concerns	35
Environmental Impact	36
Insecticide Chemical Accountability	37
Complementary Services	39
Insect Production	40
Pathogen Production	41
Greenhouse & Animal Services	42

TABLE OF CONTENTS (continued)

	Page
Information and Technical Services	43
Scientific Editing and Information Services	44
Administrative and Common Support Services	45
Library Services	46
Administration, Financial and Engineering Services	47
APPENDICES	49
Expenditures	51
Contracts	52
Organization Chart	53
Staff Listing	55
Publications, 1985-86	59

THE CANADIAN FORESTRY SERVICE

GOVERNMENT OF CANADA

The Canadian Forestry Service is the principal source of federal expertise in forestry and has been designated as the government's lead agency for forestry matters. Its general objective is to promote the wise management and use of Canada's forest resources for the economic, social, and environmental benefit of Canadians.

The following are the main functions of the CFS:

1. Coordination of federal policies for the promotion of better resource management and forest industry development.

2. Provision of scientific and technological leadership in forestry through research and development.

3. Provision and analysis of national and international statistics and information as a basis for policy formulation.

4. Development and certification of codes and standards for wood product performance.

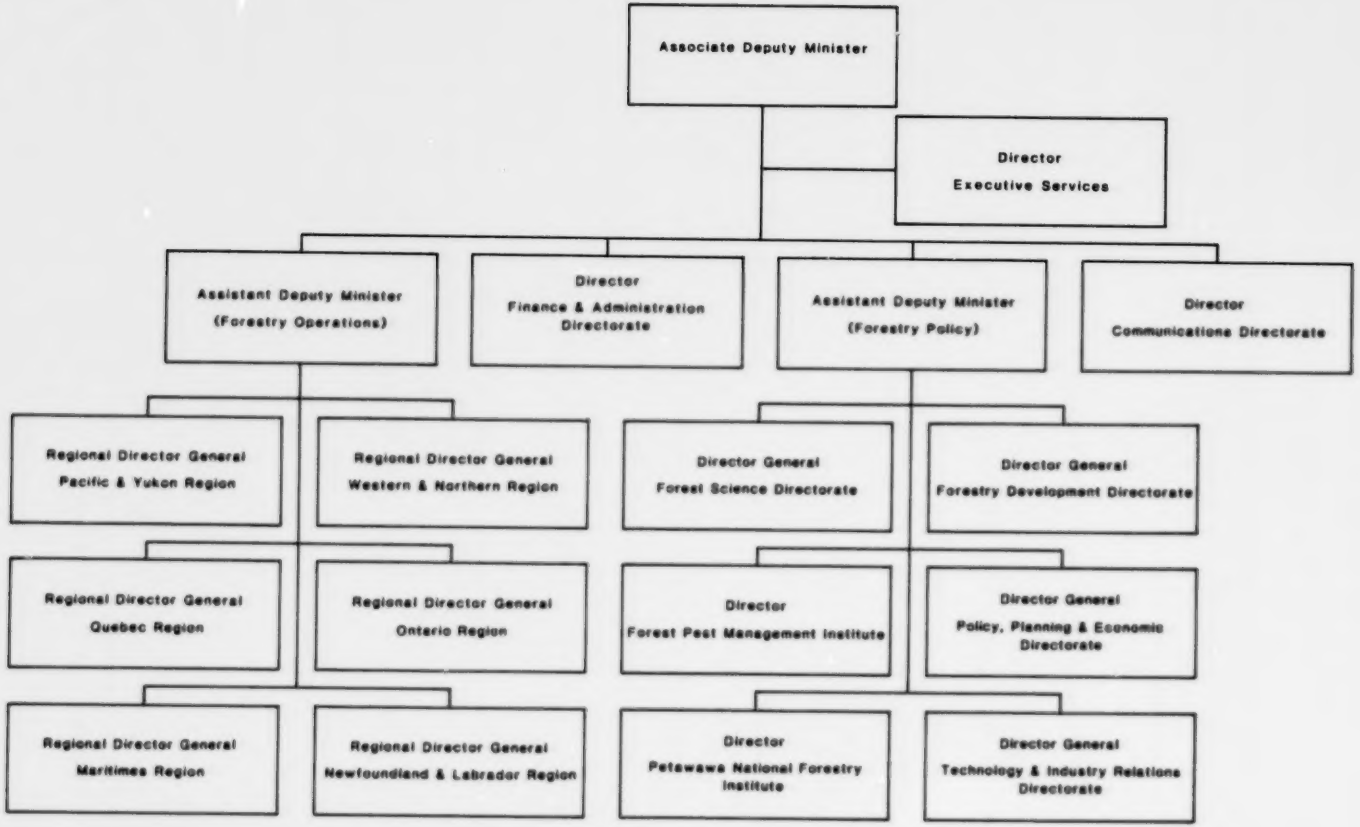
5. Protection of Canada's forest from foreign pests.

6. Fostering the potential use of the forest resource for energy.

7. Contributing to the environmental objectives of the Government of Canada.

Canadian Forestry Service programs are coordinated with those of other forestry agencies through a variety of mechanisms, including the Canadian Council of Forestry Ministers the Forest Sector Strategy Committee, management committees for Federal-Provincial Forestry Development programs, national and regional Research Advisory Committees, and various technical committees for specific program areas.

The Canadian Forestry Service is comprised of a headquarters unit, six forestry centres, and two national institutes. The forestry centres are responsive to regional priorities and maintain close liaison with the respective provincial government forestry departments and other clients. They also participate in, and frequently lead, national programs. The national institutes provide the focus for programs of national scope.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Directorate
Regional Director General
Maritimes Region
Regional Director General
Newfoundland & Labrador Region
Director
Petawawa National Forestry
Institute
Director General
Technology & Industry Relations
Directorate

SERVICE CANADIEN DES FORÊTS

GOUVERNEMENT DU CANADA

Le Service canadien des forêts (SCF) réunit la majorité des spécialistes fédéraux en foresterie; il a été désigné comme l'organisme officiel du gouvernement responsable du secteur forestier. Son objectif général est de promouvoir l'aménagement et l'utilisation judicieux des ressources forestières du Canada pour le plus grand bien économique, social et environnemental des Canadiens.

Voici les principales fonctions du SCF:

1. Coordonner les politiques fédérales afin de favoriser l'amélioration de la gestion des ressources et l'expansion de l'industrie forestière.

2. Fournir une orientation scientifique et technologique dans le domaine de la foresterie, par la recherche et le développement.

3. Fournir et analyser les statisques et l'information nationales et internationales qui serviront à établir les politiques.

4. Mettre au point et homologuer des codes et des normes en matière de rendement des produits du bois.

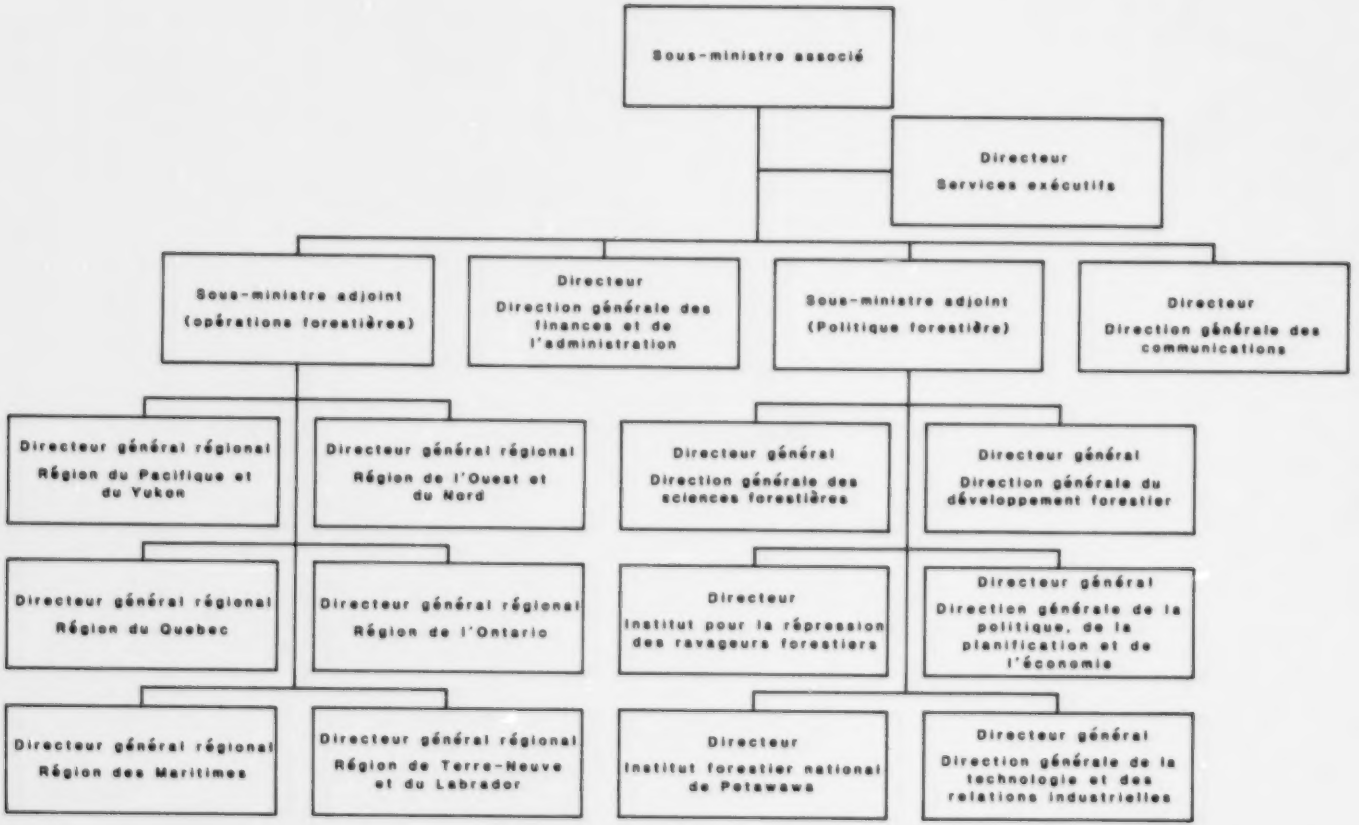
5. Protéger les forêts canadiennes en luttant contre les ravageurs étrangers.

6. Parrainer l'utilisation éventuelle des ressources forestières pour la production d'énergie.

7. Adhérer aux objectifs environnementaux du gouvernement fédéral.

Les programmes du SCF sont menés de concert avec ceux d'autres organismes forestiers par l'entremise de divers mécarismes dont le Conseil canadien des ministres des Forêts, le Comité de la stratégie forestière, les comités de gestion des programmes fédéraux-provinciaux de développement forestier, les comités nationaux et régionaux consultatifs sur la recherche, de même que divers comités techniques axés sur des domaines de programmes spécifiques.

Le SCF comprend une administration centrale, six centres de foresterie et deux instituts nationaux. Les centres de foresterie doivent répondre aux impératifs régionaux et entretenir une liaison étroite avec les ministères provinciaux des Forêts. Ils participent également à des programmes nationaux dont ils assument fréquemment la direction. Les instituts nationaux sont les foyers des programmes d'envergure nationale.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Institut forestier national de Petawawa
Directeur général
Direction générale de la technologie et des relations industrielles

Director's Foreword

Canada is a forest nation. Forestry contributes more to our balance of international trade than agriculture, mining, fisheries and fuels combined and provides one in every 15 jobs in this country. It is important to the socio-economic well-being of all Canadians that Canada's share of the foreign market in wood and wood products be maintained or increased in the years to come. However, large our forest resource may be, it is not inexhaustible and when such factors as economic accessibility, failure of natural regeneration, neglect of forest renewal on depleted productive forest lands, losses from fire, insects, diseases and competing vegetation, utilization of productive forest land for other purposes and other factors are taken into consideration, only a small margin exists for expanded future utilization. To help correct this situation, extensive programs of intensive forest renewal and forest management are being instituted in many areas of Canada which, to be successful, must incorporate the utilization of genetically superior planting stock, extensive programs of site preparation, suppression of competing vegetation, stand thinning and fertilization where required and more extensive use of forest protection practices to reduce losses from fire and from destructive insects and diseases. In short, to maximize the socio-economic benefits that can flow from our forests, we must begin to farm, not mine them. This will require the use of all silvicultural tools available to forest managers, dedication of the forestry community to the challenges presented and support of the Canadian public in these essential endeavours.

The program of the Forest Pest Management Institute addresses one important component of this broader problem - reduction to acceptable levels of losses in forest production caused by destructive forest insects and competing vegetation. These losses, which, on an annual basis, have been estimated at anywhere between one-half and two-thirds of the average annual harvest, cannot be tolerated and can be reduced through development and judicious use of pest control products. Development of such control products and of strategies for their effective and environmentally benign use is the Forest Pest Management Institute's *raison d'être* and is in direct alignment with the overall objective of the Canadian Forestry Service, "to promote the wise management and use of Canada's forest resource for the economic, social and environmental benefit of all Canadians".

As described in more detail throughout this booklet, somewhat in excess of 50 percent of the Institute's R & D program is concerned with the development of biorational control agents for use against economically important forest insect pests. Within this part of our program, we conduct the fundamental and applied research required to develop microbial control agents - bacteria, fungi, viruses and protozoa - for use against forest insect pests; we investigate the use of insect growth regulators for this same purpose; and we investigate the use of insect sex pheromones or sex attracants both for monitoring the occurrence of insect pests and for their control. This biorational control agents research is supported by fundamental research in insect tissue culture, cellular biology, immunochemistry and biological systems analysis essential for the identification of control agents, elucidation of their precise modes of action, development of improved methods for their mass production, and for determination of optimal strategies for their effective use.

A large part of the Institute's program is concerned with the development of chemical insecticides and herbicides for use against destructive forest insect pests and competing vegetation. Until biorational control agents can be developed to their full potential, we will have to rely heavily on these materials as our first line of defense in forestry and, regardless of what developments occur on the biorational side, it is almost certain that we will always have to depend upon chemical pesticides to some extent. Research in this area includes the toxicology and screening of new and/or improved insecticides and herbicides for forestry use, determination of their efficacy under field conditions and development of improved methods for utilizing them. To optimize the effectiveness of both chemical and biorational control agents, methods must be developed to deliver them directly to the target area in the precise amounts required to meet protection requirements and to minimize undesirable effects on other components of the forest ecosystem. The Institute is, therefore, significantly involved in application technology research including the effects of formulation properties on spray cloud emission and behavior, and the effect of meteorological and other factors on spray cloud behavior from emission to canopy penetration and impaction.

The responsible use of pest control products demands that their use impose minimal risk to the environment or to human health. The effects on human health lie outside the mandate of the Forest Pest Management Institute and are evaluated by appropriate federal and provincial health agencies. The Institute is, however, heavily involved in research on the environmental impact and chemical accountability of pesticides. This research is required to determine the effects of pesticides on non-target organisms in the forest environ-

ment and the persistence, dynamic cycling and ultimate fate of these products and their metabolites in the forest ecosystem.

All of these R & D thrusts are supported by a Complementary Services Project which provides the insect, plant, and pathogen production services required to facilitate the R & D program.

This Program Review booklet is designed to acquaint the reader with the Forest Pest Management Institute, its mandate and its program. Data generated within the Institute's R & D program are essential for the development of new and/or improved pest control products for forestry use and for development of strategies for their operational use which will optimize effectiveness and minimize adverse environmental impact. In addition, Institute research provides much of the data upon which the registration status of pest control products for forestry use is determined under the Pest Control Products Act and upon which effective yet environmentally benign use patterns are developed and promulgated.

G.W. Green
Director
1 April, 1987

Microbial Control Agents

A wide variety of naturally occurring insect pathogens, including bacteria, viruses, fungi, and protozoa, can have adverse effects on the survival and reproduction of forest insect pests. To increase the number of options available to the forest manager for control of economically important insect pests, biological control research at the Institute is aimed at identifying those insect pathogens that have control potential and identifying the conditions under which they can be used to prevent insect outbreaks, or to suppress them once they have occurred. When these conditions have been identified, strategies can be developed for the use of these pathogens, either by themselves or in concert with other control methods such as chemicals.

Institute research into biological control presently concentrates on three main areas; the identification of insect-specific pathogens for control use, the elucidation of the conditions under which these organisms exert their effect on naturally occurring populations, and the development of use patterns and strategies for their effective use. These projects investigate naturally occurring host-pathogen interactions, develop data necessary to support petitions for registration of candidate pathogens, and improve application strategies for registered agents. Research into a particular organism can overlap these categories in terms of understanding its natural occurrence and effectiveness and developing it for use.

FF-10 BACTERIAL PATHOGENS

PROJECT STAFF:
P.G. Fast (Project Leader), K. van Frankenhuyzen (Study Leader), R. Milne, C. Budau, C. Nystrom, L. Gringorten (Post-Doctoral Fellow)

OBJECTIVES: *To enhance the effectiveness of* Bacillus thuringiensis *and related bacterial pathogens for use in the control of forest insects in Canada.*

ACHIEVEMENTS: Much of the available knowledge on the chemistry and mode of action of the insect toxin produced by *Bacillus thuringiensis* was produced by this project. With the establishment of the BIOCIDE collaboration between CFS, NRC, and several university scientists, this knowledge base is being extended to include molecular biology and protein structure of the toxin as these relate to host range and toxicity determinants. The first field tests with *Bacillus thuringiensis* against forest insects were conducted by this project in 1959 and 1960. Development of application technology has continued ever since, contributing to the development of this bacterium as a viable option to manage outbreaks of spruce budworm, gypsy moth, jack pine budworm, hemlock looper, and other forest defoliators.

During 1986-87, work was done on a cell-suspension assay system, which will allow toxin at high pH to interface with cells at a lower pH without causing adverse pH effects on the cells. The effects of sunlight on the *B.t.* crystal were investigated. The effect of temperature on mortality, feeding inhibition and recovery of budworm larvae was investigated. Low volume application of undiluted *B.t.* was evaluated for control of the gypsy moth. The susceptibility of several forest insects to various *B.t.* strains was established in diet bioassays. Single gene isolates of *B.t.* were assayed against an array of target insects and cell cultures to define their toxicity spectra and identify response types among their target organisms.

PROJECTIONS: During 1987-88, the BIOCIDE collaboration will continue. The range of cells available for *in vitro* assay will be expanded. Spectrum bioassays will be conducted on chemically or genetically modified crystal protein or toxin materials. The influence of temperature and exposure time (i.e. residual toxicity) on acquisition of a lethal dose by budworm on foliage will be determined. The relationship between ingested dose, feeding inhibition, recovery, and mortality will be investigated. Field tests of low volume application for control of gypsy moth will continue.

FP-11 FUNGAL PATHOGENS

PROJECT STAFF:
D. Tyrrell (Project Leader), Vacant (Study Leader), C. Budau, K. Humphries, M. Welton

OBJECTIVES: *To develop methods and procedures for the use of entomogenous fungi in the management of forest insects in Canada.*

ACHIEVEMENTS: Development of culture methods has resulted in the isolation of several Entomophthorales species, which were once regarded as obligate pathogens and has led to the recognition of a new vegetative growth stage in several species. Resting spore germination in several *Erynia* species has been described and photoperiod effects have been documented. Epizootiological field studies have demonstrated the importance of such factors as host density and spatial distribution of the host, the effect of inoculum density and weather conditions on the establishment and spread of fungal pathogens. Mathematical models have been designed to describe some of these interactions.

During 1986-87, a comparative study on the pathogenesis of *Erynia radicans* and *E. aulicae* was begun. The effect of light and dark on growth of *E. aulicae* was investigated using DNA hybridization techniques in collaboration with Basil Arif. Participation in the joint GLFC/FPMI budworm survivorship studies in Lake Superior Provincial Park and at Black Sturgeon Lake continued.

PROJECTIONS: During 1987-88 collaboration will continue in the GLFC-FPMI spruce budworm survivorship study. The comparative study on *E. aulicae* and *E. radicans* will continue. A collaborative study with Dr. Otvos of the Pacific Forestry Centre (PFC) on fungal pathogens of black headed budworms will also continue. Investigations will be carried out on how to optimize storage and survivability of dried *E. aulicae* preparations.

FP-12 PROTOZOAN PATHOGENS

PROJECT STAFF:

G.G. Wilson (Project Leader), E. Young

OBJECTIVES: *To investigate the host-parasite relationships of microsporidia and determine their potential and methods for use for control of forest insect pests.*

ACHIEVEMENTS: This project was initiated in 1968, and since that time has made significant progress in elucidating the occurrence and effect of microsporidia in forest insect populations. Because of the importance of the spruce budworm as a forest pest in Canada, emphasis was given to microsporidia *(Nosema fumiferanae* and *Pleistophora schubergi)* attacking this insect. Other pest insects such as the forest tent caterpillar, jackpine budworm, and sawflies and their parasitic microsporidia have also been studied. These parasites were found to have a strong debilitating effect on their hosts, reducing adult longevity and fecundity.

During 1986-87, the study on the field ecology/population dynamics of the spruce budworm, is it relates to microsporidian prevalence and intensity, continued. A comparison was made of the effects *N. fumiferanae* and a *Nosema* sp., isolated from the jack pine budworm, had when fed to their hosts, spruce and jack pine budworms. Numerous samples of field-collected insects were examined for pathogens, of a total of 1281 insects from 23 different species, 133 were infected with a pathogen. Cultures of *Nosema fumiferanae, N. disstriae, N. whitei, Pleistophora schubergi, N. bombycis* and *Vairimorpha necatrix* were maintained.

PROJECTIONS: During 1987-88, this project will be terminated and the staff will be moved to FP-40. The primary reason for this is that research to date has shown the effects of microsporidia on their insect hosts and has confirmed that they lack potential as direct control agents, though they can exert significant pressure as sub-lethal agents. Any future research for microsporidia would be at a reduced level under FP-40.

FP-13 VIRAL PATHOGENS

PROJECT STAFF:

J.C. Cunningham (Project Leader), B. Arif (Study Leader), W.J. Kaupp (Study Leader), P.B. Jamieson, K. Brown, R. Burke, B. Cunningham.

OBJECTIVES: *To develop viruses for effective and environmentally acceptable use in the population regulation of important forest insect pests.*

ACHIEVEMENTS: Since its inception in 1949 this project has contributed a great deal to the study of insect viruses. Three viruses have been granted full registrations under the Pest Control Products Act. These are: Lecontvirus—a nuclear polyhedrosis virus (NPV) for control of red-headed pine sawfly; Virtuss, which is Douglas-fir tussock moth NPV produced in white-marked tussock moth; and TM BioControl-1, the American product identical to Virtuss. The biochemical and biophysical properties of NPVs from several budworm species, the white-marked tussock moth, Douglas-fir tussock moth, European pine sawfly, red-headed pine sawfly and gypsy moth have been elucidated. The methods used to diagnose virus infection, identification procedures and bioassay techniques have all been significantly improved.

During 1986-87, approximately 30-35 virus-specific proteins were identified in the infected host—the spruce budworm. Two plots were sprayed with gypsy moth NPV near Tweed, Ontario to determine the efficacy of this virus. An area in Newfoundland was sprayed with 2.5 x 10^{11} PIB/ha of Virtuss by ground equipment.

PROJECTIONS: During 1987-88, analysis of the viral replication cycle will continue. A network of NPV researchers will be initiated. Field research on the efficacy of *L. dispar* NPV will continue. Virtuss will be applied to an *O. leucostigma* population in Newfoundland. Epizootiological studies will be completed on *L. dispar* NPV. Bioassays of small RNA viruses and *C. fumiferana* NPV will be completed.

Biological Interactions

In a research program as broad as that of the Institute there is an essential requirement for research into the biological effects of a variety of insect pest control methods, and for systems to study modes of action and identification. To conduct such research, and to develop the information required to successfully carry out other Institute projects, four areas are investigated. These are: Tissue Culture, for the study of insect pathogens *in vitro;* Cell Biology, for the identification of normal cellular development and its alteration by control agents; Immunochemistry, for identification and characterization of pathogens and their constituents; and Biological Systems Analysis, for modelling and analysis of the underlying biological systems, assistance in experimental design, and methodology for interpretation and integration of results. In addition to significant individual contributions, these projects have strong ties across the Institute's research program.

FP-20 INSECT PATHOGENS *IN VITRO*

PROJECT STAFF:

S.S. Sohi (Project Leader), G. Caputo, B. Cook

OBJECTIVES: *To develop and apply insect tissue culture methodology for the* in vitro *investigation of insect pathogens with a view to enhancing their effectiveness in the management of forest insect pests.*

ACHIEVEMENTS: This project has produced over 50 continuous cell lines from the eastern and western spruce budworms, forest tent caterpillar, white-marked tussock moth, red-headed pine sawfly and the tobacco hornworm. Species identity of most of these cell lines has been confirmed by chromosomal, serological and isozyme analyses. We have produced spruce budworm cells in suspension cultures of up to 2 liters. We have also developed a methodology for the deep-freeze storage of insect cell cultures and protoplasts of entomogenous fungi. Nuclear polyhedrosis viruses and microsporidia have been propagated in several of these cell cultures. Some of the cell lines have been used for the *in vitro* bioassay of *Bacillus thuringiensis* delta-endotoxin.

During 1986-87, a methodology was developed to produce and isolate plaques of the CfNPV. Much time was spent studying the factors that affect the multiplication of CfNPV in FPMI-CF-70 cells. Collaborative work was done, with Basil Arif, on virus-specific protein synthesis of CfNPV in FPMI-CF-70 cells, and with Paul Fast to develop a new *in vitro* bioassay for the *B.t.* delta-endotoxin.

PROJECTIONS: During 1987-88, collaborative work will be done with Paul Fast, on a cell culture bioassay for the *B.t.* delta-endotoxin with Basil Arif, on virus-specific protein synthesis of CfNPV; and with Bill Kaupp, to study the replication of CfNPV in CF-70 cells using electron microscopy.

FP-21 CELLULAR INTERACTIONS

PROJECT STAFF:

W.J. Kaupp (acting Project Leader), J.A. MacDonald, D. Nicholson

OBJECTIVES: *To investigate the differentiation of tissues and cells involved in the production of normal developmental patterns in insect embryos and larvae; as well as examining elaboration and transport of biosynthesized biologically active compounds or the transport of exogenous insect control agents.*

ACHIEVEMENTS: This project was initiated in 1979 by combining several current or proposed structural studies, all of which were related to the transport within insects of biologically active agents or pest control agents. Morphological and ultrastructural studies were conducted on exocrine glands in 11 species of arthropods, including the sex pheromone glands of 7 species of Lepidoptera. Ultrastructural analyses were done on the mode of action of *B.t.* in the midgut cells of silkworm and tobacco hornworm larvae. Investigations were carried out on the multiplication of viruses in host larvae and in cell cultures.

During 1986-87, supervision of this project was assigned to Dr. W. Kaupp. A series of ultrastructural studies on *T. ni* eonocytes was completed. Work was begun on development of methods for processing tissue culture cells for electron microscopy. Experiments continued on the autoradiographic location of protein and chitin synthesis in spruce budworm larvae.

PROJECTIONS: During 1987-88, because of resource and person-year restrictions, this project will be terminated Resources will be transferred to a newly established Research Services study--Electron Microscopy Services.

PP-22 IMMUNOCHEMISTRY

PROJECT STAFF:

A. Pang (Project Leader), B. Mathieson

OBJECTIVES: *To develop and apply immunochemical techniques to the identification, characterization and genetic manipulation of insect pathogens, thus improving the quality of the biological pest control agents.*

ACHIEVEMENTS: The project was reorganized in 1985, when the current project leader came on staff. A hybridoma laboratory has been set up and is ready for in-house production of monoclonal antibodies: hybridomas produced at Queen's University under a PRUF contract have been partially transferred to this laboratory. Investigations have been initiated on the immunochemical structure of the *B.t.* delta-endotoxin. Immunologic probes have been developed for the surface proteins of the *Choristoneura fumiferana* nuclear polyhedrosis virus (CfNPV).

During 1986-87, research continued on the identification of *B.t.* toxin receptors and on the immunochemical structure of the *B.t.* delta-endotoxin and its mode of action. The hybridoma laboratory became functional late in 1986.

PROJECTIONS: During 1987-88, all hybridomas will be transferred from Queen's University to FPMI and tests will be done on their specificities. The activation process of *B.t.* crystals will be studied. All the CfNPV monoclonal antibodies will be screened.

FP-23 BIOLOGICAL SYSTEMS ANALYSIS

PROJECT STAFF:

R.A. Fleming (Project Leader), T. Burns

OBJECTIVES: *To apply a systems analysis approach in research contributing to the development of solutions to forest pest management problems.*

ACHIEVEMENTS: This project was established in 1980. Major contributions of the project include work on the experimental design and statistical analysis on two environmental impact studies: one to determine suitable buffer zones around productive water bodies during permethrin sprays and the other to determine the effect of aerial applications of Zectran on forest songbirds. The project has collaborated in the development of mathematical and statistical methods for using survey data to describe short-term spruce budworm behavior and to assess the effect of operational control efforts on a broad geographic basis, and to test the forecasts of large-scale simulation models.

During 1986-87, new computer procedures for the fungal pathogen-spruce budworm model were formulated and are now being incorporated in the full model. Programs for data entry and analysis for a collaborative study of jack pine cone crop damage were completed.

PROJECTIONS: During 1987-88, testing will begin on these new procedures in a phenological development model. Jack pine cone crop life tables will be updated. Exploratory analysis of spruce budmoth impact and white pine weevil emergence data sets will begin. Data on the effect of *B.t.* dosage on budworm feeding will be analysed.

Physiological & Genetic Mechanisms

A forest insect pest grows and develops through a complex and interrelated series of steps including larval and pupal stages, mating, and reproduction. As knowledge of the physiological and genetic mechanisms associated with such development becomes more complete, so do the opportunities to identify critical stages that can be manipulated to control economically important insect pests. The Institute program in this area includes research into the physiological mechanisms associated with normal growth and development, the physiological and behavioral aspects of insect mating and reproductive behavior, and the dynamics of insect population genetics. The possibility of manipulating these mechanisms, through chemical or other means, to the detriment of insect survival within a generation, and from one generation to the next, arises from this research. Studies in these areas lead directly to the screening of candidate insect growth regulators and pheromones that have potential for use and the development of methods for their use.

FP-30 PHEROMONES

PROJECT STAFF:

G.G. Grant (Project Leader), D. Frech, Vacant (Technician)

OBJECTIVES: *To advance the use of sex pheromones and related behavior modifying chemicals for the management and monitoring of forest insect pests by providing the requisite knowledge on their chemical identification, behavioral function, and practical application.*

ACHIEVEMENTS: The project has contributed to the pheromone identification of five major forest pests, including the spruce budworm, and has discovered, through EAG bioassay and empirical field screening, effective sex attractants for a number of other important pest species. The project has assisted in developing some of these attractants into monitoring tools for insect population surveys. Through a cooperative CANUSA-sponsored project, a bacterial bioluminescence bioassay was developed for measuring low levels of aldehyde sex pheromones, such as that of the spruce budworm. The project has also made significant contributions to several areas of basic pheromone research, including lepidopteran mating behavior and its control by pheromones, and male sex pheromones and their glandular sources.

During 1986-87, the pheromone of the spruce coneworm was identified and submitted for publication. Field tests were conducted in Ontario and Newfoundland to evaluate identified sex pheromone components of fir coneworm. A field screening test in southern Ontario was done to evaluate candidate attractants for white pine coneworm. The evaluation of white pine weevil attractants was replicated successfully and the effects of lure concentration were confirmed. Lures were prepared and supplied to FP-52 as a part of a cooperative study to develop a pheromone monitoring system for the spruce budmoth.

PROJECTIONS: During 1987-88, field tests will be conducted in Ontario and Newfoundland to optimize identified pheromone components of the spruce coneworm. Further gas chromatograph (GC) analysis, EAG and behavioral bioassays will be conducted to identify pheromone components of the fir coneworm. Pheromone extract of the large aspen tortrix will be analyzed by GC. Evaluation of nonsaturating traps and lure specifity for the oak leaf shredder will continue.

FP-31 INSECT GROWTH REGULATORS

PROJECT STAFF:

A. Retnakaran (Project Leader), L.F. Smith, W. Tomkins

OBJECTIVES: *To evaluate and develop the rational use of Insect Growth Regulators for the control of insect pests of Canadian forests by investigating the physiological, morphological, and biochemical effects of various IGRs that adversely interfere with metamorphosis in forest insect pests as well as model insects.*

ACHIEVEMENTS: This project has been investigating such alternative means of forest insect control as chemosterilants, radiation, and hormone analogs since 1968. Some of the successes have been control of the spruce budworm by the moult inhibitor CGA-112913 and control of the hemlock looper by the hormone analog ZR-515. The effects of more than 50 juvenile hormone analogs have been tested on several species of Homoptera, Lepidoptera and Coleoptera. Diflubenzuron (Dimilin), a moult inhibitor, has been successfully field tested against the forest tent caterpillar, the oak leaf shredder, and the eastern hemlock looper. The data from these tests are being used in the registration package for Diflubenzuron. The biochemical mode of action of moult inhibitors on the inhibition of chitin biosynthesis and ultrastructural changes induced during metamorphosis have been studied in detail.

During 1986-87, studies were initiated on white pine weevil behavior at Thessalon, Ontario. Several new IGRs from BASF, Duphar and Sumitomo were evaluated. Protein, RNA, DNA, and lipid changes in juvenile hormone analogue-treated insects were studied.

PROJECTIONS: During 1987-88, stickers and IGR-ovicides will be evaluated as white pine weevil control agents Benzoylphenyl urea effects on insect cuticle will be studied. Laboratory and greenhouse evaluations will be done on new IGRs. IGRs will be field-tested against the spruce budmoth, the gypsy moth and the hemlock looper.

Pesticide Toxicology & Efficacy

A wide variety of forest insect pests inflict severe damage on Canadian forests each year. The best estimates currently available suggest that the average loss in wood volume caused by the activities of our major forest insect pests approaches or exceeds some 63 million m^3 per annum. In addition, competition from undesirable tree species, grasses, and weeds often impedes the establishment, survival, and growth of desired crop species by as much as 50%. Losses of this dimension cannot be tolerated if Canada is to meet wood production goals accepted by the Canadian Council of Resource and Environment Ministers for the year 2000, or if we are to maintain Canada's share of the foreign market in wood and wood products, which is so vital to our national economy. Such losses can be prevented, or at least reduced substantially, by the judicious use of pesticides. Most insecticides and herbicides, however, are developed by the pesticide industry first for the agricultural use market, which is very large and stable compared to the forestry use market. Before such materials can be registered and used for forestry purposes, their efficacy against forest insect pests and unwanted vegetation must be determined and dosage rates that will balance efficacy and acceptable environmental impact must be established.

To help ensure that forest managers have a range of effective insecticide and herbicide alternatives available for their use, the Institute maintains a continuing program that screens new products and modified formulations of existing ones, to determine toxicity against a range of target pests. Those pesticides that appear to have potential for forestry use are tested in a series of field efficacy trials to establish actual use potential, required dosage rates, and use patterns after full consideration has been given to the biology of target pests and host species. The data generated by this program become essential components of the data package that is eventually submitted in support of registration of these pesticides for forestry use under the Pest Control Products Act. They also form the basis of control recommendations to forest managers.

FP-50 INSECTICIDE TOXICOLOGY

PROJECT STAFF:

B.V. Helson (Project Leader), D. Comba, J. McFarlane

OBJECTIVES: *To determine the toxicological properties of insecticides and other chemicals on forest pests and selected non-target organisms.*

ACHIEVEMENTS: This project was initiated in 1965 when there was a critical need to find effective insecticides to replace DDT. Since then, the toxicological properties of over a hundred chemical insecticides have been investigated on spruce budworm and numerous other forest insect pests. The insecticides fenitrothion, aminocarb, acephate, and permethrin - all now registered for forestry use - were originally identified through this project. The emphasis of the project has recently shifted to studies on factors influencing the toxicity of current products, development of existing insecticides for other insect pests, and the safety of these insecticides to non-target organisms.

During 1986-87, studies were completed on the toxicity of Zectran, Larvin and AC217-300 to spruce budworm larvae, and tests with a new insecticide, SAN 811-I were started. Experiments were also conducted to assess the effects of host foliage, dropsize, temperature and foliar residue levels on the toxicity of insecticides to budworm larvae. Studies were continued to determine the toxicological properties of selected insecticides to black army cutworm, hemlock looper, jack pine budworm and white pine weevil and a study on debarking beetles was initiated. A trial was conducted to measure the persistence of UC84572 an experimental IGR,in comparison with Dimilin in aquatic habitats using mosquito bioassays.

PROJECTIONS: During 1987-88, toxicological research with SAN811-I and microencapsulated permethrin is planned to determine their potential for spruce budworm control. Studies will be continued to examine the effects of weather, dropsize host foliage type, and foliar residue levels on insecticide toxicity. Further toxicological research will be done with hemlock looper jack pine budworm, white pine and debarking weevils while new studies will be initiated with gypsy moth and cone beetles. The persistence of UC84572 will be measured again and the toxicity of fenitrothion to nontarget insects will be examined further.

FP-51 INSECTICIDE FIELD EFFICACY

PROJECT STAFF:

B.L. Cadogan (Project Leader), P. Ebling, B. Zylstra

OBJECTIVES: *To develop suitable methodology and data to assess the efficacy of insecticides, formulations, and pest control strategies as required for the management of forest insect pests.*

ACHIEVEMENTS: Since its inception in the mid-1950s this project has been primarily concerned with field efficacy testing of insecticides with potential for forestry use. Data arising from this project have been used to assess the efficacy of virtually all insecticides currently registered for forestry use in Canada today. Methods of applying these materials in a manner that optimizes effectiveness while minimizing environmental impact have been developed. Between 1981 and 1985, the project conducted field studies on seven insecticides and provided experimental data for registration submissions for five of them. The project has examined and assessed four types of spray dispersal equipment and developed a technique to assess sprays in conifers.

During 1986-87, the plans involving Sumithion flowable, Futura XLV, and Matacil had to be cancelled because of a decision by the Ontario Legislature to ban chemical spraying on Crown Lands. Research was begun on the influence of weather stability on the efficiency of a pesticide spray using a pesticide mimic. Evaluation of a sampling apparatus and technique continued. Spruce budworm population development was investigated on three common host species — balsam fir, white spruce, and black spruce.

PROJECTIONS: During 1987-88, the field efficacy of a reduced volume of Sumithion flowable against spruce budworm will be determined Field trials will be conducted to evaluate Futura XLV *(B.t.)* and two improved Dipel *(B.t.)* formulations against the spruce budworm. Research on the influence of weather stability on the efficiency of pesticide sprays will continue. New AV 4000 rotary atomizers will be evaluated.

FP-52 PLANTATION PEST MANAGEMENT

PROJECT STAFF:

J. Turgeon (Project Leader), P. de Groot (Study Leader), N. Nelson, A. Obarymskyj

OBJECTIVES: *To develop integrated protection systems for insect pests of coniferous plantations grown for seed and lumber production.*

ACHIEVEMENTS: This project has been involved in collecting biological, ecological, and behavioral information on the spruce budmoth, a pest of white spruce plantations, since 1982. Insecticides have been screened and field-tested for the control of this pest--permethrin was the only insecticide to meet desired protection levels under field conditions. Sampling schemes have been developed and a sex attractant was identified. This project was also involved in a cooperative effort to establish buffer zones around water bodies during ground and aerial application of permethrin.

During 1986-87, several sites in northern Ontario were selected for a study on black spruce cones. Life tables were constructed for natural stands. Life history and behavioral data were collected for *Conophthorus banksianae,* a pest of jack pine seeds. The leader of the Protection Strategies and Techniques Study enrolled in a Ph.D. program in 1986 at Simon Fraser University.

PROJECTIONS: During 1987-88, research will be done to identify families of white spruce that are less susceptible to spruce budmoth. Field studies will continue on mortality factors of black spruce and jack pine cones. The development of sampling schemes for cone and insect pests of cones will be initiated. Studies on the host specificity of *C. banksianae* and *C. resinosae,* two mortality factors of jack pine seeds, will continue.

FP-54 HERBICIDES DEVELOPMENT AND USE

PROJECT STAFF:

P. Reynolds (Project Leader), R. Prasad (Study Leader), D. Thompson (Study Leader), L. MacDonald, D. Pitt, B. Staznick, D. Travnick

OBJECTIVES: *To develop data required for the registration of herbicides for forestry use in Canada and to develop new and improved use strategies for forestry herbicides that provide maximum crop tree growth response with minimal environmental impact.*

ACHIEVEMENTS: The FPMI herbicides project was initiated in 1981 in response to concerns of forest managers about the scarcity of vegetation management tools. A comprehensive protocol was established for the evaluation of new herbicides under laboratory, greenhouse, and field conditions. Operational aerial herbicide field trials began in 1984-85 and have included efficacy, crop tolerance, and residue research with Velpar and Roundup in New Brunswick and British Columbia. The effects of herbicide droplet size and spray adjuvants on efficacy against weeds and crop injury are being studied under greenhouse conditions.

During 1986-87, a third-year vegetation assessment of the New Brunswick Velpar site preparation trial, and a second-year vegetation assessment for the 1984 Carnation Creek Roundup trial were conducted. Trials were conducted in New Brunswick with Ally, Oust, and Pronone. Greenhouse and small field plot studies on droplet size and herbicide adjuvants continued. A modified spray system for use in small plots was tested. Analytical methods were developed for the extraction and cleanup of glyphosate residues in soils, sediments, and leaf litter. Field samples collected in the Carnation Creek studies were analyzed.

PROJECTIONS: During 1987-88, vegetation analysis will continue at the 1984 New Brunswick Velpar site, the 1984 Carnation Creek Roundup site, and the 1986 New Brunswick and Ontario site preparation trials. Comparative brush herbicide site preparation trials will be held in New Brunswick. Screening the effects of adjuvants, and the effects of droplet size on herbicide efficacy will continue. Carnation Creek residue analysis will be completed.

Application Technology

The ultimate goal in the operational application of any pesticide by whatever application method is to assure that only the essential required amount of the pesticide is emitted, and that as much of the emitted material as possible reaches the intended target in a form that optimizes its effectiveness against the target pest. If this goal is achieved, drift beyond the target area is minimized and the effectiveness of the pesticide against its intended target is maximized.

A great number of factors affect achievement of this ultimate goal. For example, the physicochemical characteristics of liquid sprays affect the production size, and evaporation of the spray droplets. Dispersal system design, nozzle type, pressure, flow rate of the emission system, and speed of the vehicle carrying the emission system also influence the droplet pattern produced. Meteorological conditions during application affect the movement of the spray cloud, evaporation of the droplets, and penetration into and impaction on the forest canopy.

A thorough understanding of all of these factors and their interactions is essential if pesticides are to be applied in the most economical, efficacious, and environmentally acceptable manner. Therefore, research into all of these areas is an important aspect of the Institute's overall R & D program.

FP-61 PESTICIDE FORMULATIONS

PROJECT STAFF:

A. Sundaram (Project Leader), J. Leung

OBJECTIVES: *To asses and/or modify the physicochemical properties and behavior of pesticide formulations in order to improve upon stability, handling, dispersal, and deposition characteristics required to maximize efficacy and to minimize environmental impact.*

ACHIEVEMENTS: This project has been investigating the behavior of spray formulations since its inception in 1980. A spray chamber is used to study the influence of formulation ingredients on spray droplet spectra, impaction, and retention on targets. Field studies have been conducted in Ontario and New Brunswick to investigate the role of formulation properties on pesticide performance. The project participates with other projects and outside agencies in the areas of application technology, spray deposit assessment efficacy, and environmental effects.

During 1986-87, the influence of additives and temperature on the physical properties of nonaqueous pesticide formulations and diluent oils was successfully investigated. A method was developed to determine the mechanism of atomization of herbicide formulations containing an anti-drift adjuvant. Cooperative work with other FPMI projects and outside agencies continued.

PROJECTIONS: During 1987-88, laboratory tests will be carried out to determine the optimum range of physicochemical properties of forest herbicide and *B.t.* formulations with and without adjuvants. Methods will be developed to define degrees of droplet spreading and adhesion on target and non-target surfaces and to determine rainfastness of spray droplets on target surfaces.

FP-62 PESTICIDE ATOMIZATION AND DISPERSAL

PROJECT STAFF:

N. Payne (Project Leader), J. Beveridge

OBJECTIVES: *To advance knowledge of spray formation, dispersal and deposition, with a view to improving pesticide application techniques by increasing efficacy, reducing off-target deposit and the cost of forestry pesticide applications.*

ACHIEVEMENTS: During 1985-86 the former Dispersal Systems and Spray Cloud Behavior projects were merged to form the Pesticide Atomization and Dispersal project. In the 1970's the Dispersal Systems project made important contributions to research into application technology for ULV insecticide applications, and the Spray Cloud Behavior project pursued research into the effect of meteorological conditions on drop deposit from ULV applications to determine how insecticide efficacy might be affected. Both projects were without scientists for several years, FP-60 from 1980 to date, and FP-62 from 1978 to 1983. Since 1983 the Spray Cloud Behavior project has carried out research into spray drift, which causes off-target deposit. Experimental techniques to quantify spray drift have been developed and used in a number of herbicide and insecticide trials employing a range of use strategies. A novel technique has also been developed for setting buffers around areas sensitive to pesticides, and this has been applied to the forestry use of the herbicide glyphosate and the insecticide permethrin.

During 1986/7 experimental trials were carried out to measure off-target deposit from aerial herbicide applications made under different meteorological conditions. Research into herbicide atomizer characterization has been carried out and supervised by FP-62. This research enables atomizers and settings to be selected that will provide better herbicide efficacy with less off-target deposit.

PROJECTIONS: For 1987-88, this project has secured funds under the Canada-Ontario Forest Resource Development Agreement to carry out collaborative research on drift and phytotoxicity resulting from low volume herbicide applications. This research will be used in assessing the usefulness of this type of application, and in setting buffers.

Environmental Concerns

Before a pesticide can be used in Canada it must be registered under the Pest Control Products Act, which is administered by Agriculture Canada. Under the terms of this Act, a pesticide must be proved effective and its use must not have a significant, adverse impact on environmental quality or on human health. To have such materials registered for forestry use in Canada and to develop the most appropriate use patterns for them, it is essential that we have an adequate understanding of their impact on non-target, naturally occurring species in the forest environment, and of their persistence, mobility, and ultimate fate in that environment. While such knowledge is essential for registration purposes, it is just as essential in adequately addressing public concerns relating to the use of these forest management tools.

A significant portion of the Institute's technical expertise and resources are directed toward determination of the effect of pesticides (chemical and biological) on non-target avian, terrestrial, and aquatic organisms in the forest environment and to elucidation of the occurrence and fate of these materials, and their breakdown products in foliage, soil, litter, water, and bottom sediment after application.

FP-70 ENVIRONMENTAL IMPACT

PROJECT STAFF:

P.D. Kingsbury (Project Leader), K. Barber, S.B. Holmes, D.P. Kreutzweiser, R. Millikin, K. Mortensen

OBJECTIVES: *To develop necessary experimental methods and carry out field and laboratory studies to determine potential environmental impacts of forestry pesticides on forest ecosystems and to develop and recommend pest management strategies and pesticide use patterns to minimize these impacts under operational conditions.*

ACHIEVEMENTS: Over the past decade this project has worked with other FPMI and CFS projects to evaluate the environmental effects of numerous candidate chemical and biological insecticides and has re-evaluated operational materials that came into use prior to current stringent registration requirements. Work on products such as fenitrothion, aminocarb, *B.t.*, permethrin, acephate, nuclear polyhedrosis viruses, carbaryl and others has helped define the potential and conditions for using these products in forest environments without causing undue harm to non-target communities. A great deal of effort has gone into developing methods for monitoring the effects of forest pest control operations and transferring these techniques to regional agencies in Quebec, Newfoundland, New Brunswick, Ontario, British Columbia, and Nova Scotia. More recently, emphasis has shifted to integrating field and laboratory studies to elucidate risk and response relationships of pesticide/forest community interactions.

During 1986-87, baseline data collection on brook trout populations, aquatic invertebrates and tracer dye movement in the Icewater Creek watershed was completed. Aquatic impact studies on Dimilin were carried out in forest ponds in the vicinity of gypsy moth infestations in southern Ontario. Monitoring techniques to measure insecticidal impacts on solitary bees and plant fecundity were evaluated. The intensive field program to evaluate fenitrothion's effect on songbird behavior was completed with the ground-spray treatment of the study block. Aquatic invertebrate toxicity studies with Dimilin were pursued through a PRUF contract.

PROJECTIONS: During 1987-88, Icewater Creek brook trout study sites will be treated with permethrin: trout and invertebrate responses will be determined. Field research to develop a protocol for using *Polygonatum* in an impact monitoring system will be completed. The Icewater Creek songbird impact program will be written up for publication. Laboratory toxicology studies with caged songbirds will be initiated.

FP-71 INSECTICIDE CHEMICAL ACCOUNTABILITY

PROJECT STAFF:

K.M.S. Sundaram (Project Leader), R. Nott, J. Broks

OBJECTIVES: *To develop analytical methodology and to determine the environmental distribution, degradation, dynamics, persistence, and metabolic fate of forest insect control products in order to help in the evaluation of their benefits and potential risks to the ecosystem.*

ACHIEVEMENTS: Since its inception in 1971, this project has researched the metabolism, fate, persistence, dynamics, and toxic potential of organochlorines, organophosphates, carbamates, pyrethroids, and IGRs and evaluated their benefits and risks to the forest environment. The data generated by this research were used in registration packages for many products. Sampling techniques have been developed for the detection and characterization of pesticide residues and adjuvants in diverse forestry substrates. The project participated in the cooperative study to establish biologically acceptable buffer zones around water bodies.

During 1986-87, the uptake, translocation persistence, and fate of C-14 mexacarbate in conifers was determined. A method to minimize volatilization of mexacarbate from formulated spray mixes and to prolong the half life of the active material in conifer foliage was successfully investigated. The distribution, persistence, and fate of diflubenzuron in some terrestrial and aquatic components of a conifer forest environment were evaluated. Methods were developed for the separation, isolation, and identification of various pesticides and their metabolites from different substrates.

PROJECTIONS: During 1987-88, the environmental fate and impact of permethrin in a stream ecosystem will be investigated with FP-70 at Icewater Creek. A simulated aquatic ecosystem to investigate the partitioning of pesticides to aquatic organisms will be developed. A two-year study will be initiated on the distribution and fate of different pesticides in simulated micro-ecosystems.

Complementary Services

A wide range of services that can produce the insect species, pathogens, and plant material required for laboratory research and field testing are essential to the research being conducted at the Institute. Insects provided by the Insect Production section are used in a variety of laboratory experiment and testing programs, for production of insect viruses for field testing and operational use, and for distribution to a number of cooperators within and outside the CFS. The Pathogen Production section produces viruses for testing, and indeed, is presently the sole source for the two insect viruses registered for forestry use in Canada. The Plant Production section grows a variety of plant species required for insect food and for screening of biological and chemical insecticides, as well as representative desirable and undesirable species for use in screening of herbicides with potential for use in Canadian forestry.

FP-40-1 INSECT PRODUCTION

PROJECT STAFF:

D. Grisdale (Study Leader), K. Barratt, L. Harwood, H. Lauzon, A. McMorran, S. White

OBJECTIVES: *To develop and carry out insect rearing methods that will provide the numbers and varieties of insects required by Institute research projects, and to supply other research cooperators as Institute priorities and resources permit.*

ACHIEVEMENTS: Since 1963, the insect production section has developed into the largest of its kind in Canada, supplying insects not only to FPMI but also to various CFS establishments, universities and other research centres in Canada and the U.S. Some twenty insect species are reared, with numbers totalling over 5 million. Non-diapause strains of some insects have been developed, and laboratory cultures of previously unreared insects have been established. About 10,000 litres of artificial diet are prepared and dispensed annually. Artificial diets are changed or modified to provide better insect growth or to establish new insects on diet, thus reducing the need to produce large quantities of greenhouse material.

During 1986-87, a high level of insect production continued, with spruce budworm (4.3 million) the principal insect raised again. A laboratory culture of fir coneworm was established. About 0.5 million gypsy moth larvae were supplied to the Pathogen Production Section during the winter months. In early 1986, the Insect Rearing Section was moved from the Cameron Building to the new FPMI complex; adjustments and modifications to rearing techniques and equipment resulted. Silkworms were successfully reared through all larval stages on an artificial diet developed in Japan. The rearing technique for black army cutworm was improved.

PROJECTIONS: During 1987-88, production will continue at a high level, with types and numbers reared depending on demand. Improvements will continue to be made to rearing methods.

FP-40-2 PATHOGEN PRODUCTION

PROJECT STAFF:

J. McPhee (Study Leader), H. Wigney

OBJECTIVES: *To develop, adapt, modify, and apply sophisticated methodology to mass production of viruses and protozoa for subsequent use in the regulation of forest insect pests.*

ACHIEVEMENTS: The pathogen production section has supplied pathogens (predominantly virus) for field trials since 1970. A variety of viruses have been produced for research purposes: nuclear polyhedrosis (NPV); granulosis (GV), and entomopoxvirus (EPV) for the eastern spruce budworm; NPV for the Douglas fir tussock moth, forest tent caterpillar, the bruce spanworm, winter moth, jack pine budworm, European pine sawfly, the red-headed pine sawfly, and other sawfly species. Two of these viruses are registered for forestry use in Canada - Virtuss for the Douglas fir tussock moth and Lecontvirus for the red-headed pine sawfly.

During 1986-87, the Pathogen Production Section moved to its new quarters in the GLFC/FPMI complex. Methods and techniques were developed for the successful production of gypsy moth NPV. Virtuss and Sertifervirus were produced. Viruses were supplied to collaborators to conduct field trials in Newfoundland and the United States.

PROJECTIONS: During 1987-88, virus production will continue to meet Institute research needs and requests from clients. Virus production and formulation will be improved with new technology and equipment. Small scale field tests will be carried out on a new technique for field propagation of sawfly NPVs.

FP-40-4 GREENHOUSE & ANIMAL SERVICES

PROJECT STAFF:

D. Buckley (Study Leader), S. MacLeod

OBJECTIVES: *To adapt, develop, extend, and apply sophisticated methodology in plant production and animal rearing that will provide, as required, material for use in the Institute's research program.*

ACHIEVEMENTS: The greenhouse section provides a wide variety of potted trees and food material for insect rearing in large numbers and on a year round basis. Greenhouse facilities are also provided for screening of insecticides and herbicides under controlled environmental conditions and for the production of coniferous and deciduous tree species for various research projects. The small animal rearing facility maintains a few rabbits and mice, which are used by the virology, bacteriology and immunochemistry projects.

During 1986-87, the greenhouse section provided a variety of plants and potted trees for screening or research studies. Approximately 3500 potted trees were supplied to researchers for screening programs. Approximately 800 larch, balsam fir, and jack pine were flushed to provide foliage for insect food. Small amounts of alfalfa and wheat were grown as insect food for small experiments. About 20 kg of mulberry foliage are provided weekly and 10 tomato plants are produced at 6 week intervals for oviposition.

PROJECTIONS: During 1987-88, greenhouse services will be maintained, culture methods will be improved and the inventory of plant material will be increased. The present FPMI greenhouse will be replaced.

Information & Technical Services

No research can be considered complete until the results have been transferred effectively to potential users. Because FPMI is closely associated with other federal departments, other governments, private industry, and the Canadian public, it is essential that results from the FPMI research program reach the publics for which they are intended. The Scientific Editing and Information Services Unit is responsible for developing and modifying the packaging and format of reports to meet changing demand; providing an editorial capability in both official languages; preparing and issuing regularly scheduled publications according to schedule; and, responding to requests for information.

The Information and Technical Services Unit at the Institute provides these and other services, contributing in a significant manner to the overall program at FPMI.

FP-93 SCIENTIFIC EDITING AND INFORMATION SERVICES

PROJECT STAFF:

K.B. Jamieson (Project Leader), S.A. Stitt

OBJECTIVES: *To publish and disseminate scientific and technical information that arises from the Institute's program in the most appropriate form to facilitate the transfer of forest pest management science and technology to user groups.*

ACHIEVEMENTS: Since its reorganization in 1983, the project has provided editorial, information, and graphics services for the Institute. Two new publications—the FPMI Newsletter and the Technical Note Series were initiated.

During 1986-87, the project handled the publication of 24 journal papers, 9 english information reports, 1 french information report, 3 issues of the FPMI Newsletter, 2 Technical Notes, the Program Review, and 8 miscellaneous reports. Ten submissions for Symposia and Proceedings were edited and sent for review. Also during this time 1,763 journal reprints, 2,304 information reports, 249 French information reports, 377 Technical Notes, and 3 French Technical Notes were distributed. The project participated with Village Audio Visual in the production of the FPMI video. The French bibliography and English supplement to the bibliography were published.

PROJECTIONS: During 1987-88, effective and efficient editing and production of Institute R & D publications will continue. Possible acquisition of electronic publishing equipment will be investigated with the GLFC/FPMI Electronic Publishing Committee. Involvement in the GLFC summer tour program will begin.

Administration & Common Support Services

Administrative Support Services (materiel management, records management, office services, fleet management, operation and maintenance of physical plant) and financial services are provided to both the Forest Pest Management Institute and the Great Lakes Forestry Centre through one administrative unit carried on the Great Lakes Forestry Centre allocation but responsible to the Directors of both establishments. Integration of these services has been total since 1978. Some economies in staff have resulted These integrated services have functioned in a highly satisfactory manner since their inception and are considered the most appropriate organizational option for sister establishments of the same service sharing the same physical facility.

Integrated joint library services are provided to both establishments in a similar fashion with permanent library staff carried on the Great Lakes Forestry Centre allocation. This, too, has resulted in some economies in both staff and library space with the added advantage that library equipment and other facilties do not have to be duplicated.

As opportunities present themselves in the future, the desirability of further integration of common support services will be investigated thoroughly with the Great Lakes Forestry Centre.

FP-94 LIBRARY SERVICES

PROJECT STAFF: (GLFC)

OBJECTIVES: *To develop, maintain, and improve a research library commensurate with the changing requirements of the combined programs of the Great Lakes Forestry Centre and the Forest Pest Management Institute.*

ACHIEVEMENTS: The joint library has served both FPMI and GLFC well since its inception in 1978. It provides roughly 400 journals 24 abstracting journals, and 8,000 reference texts to its clients at the two establishments.

During 1986-87, the library handbook was revised. Shelving to allow adequate room for growth of the collection for the next five years was obtained and installed. Monitoring and streamlining procedures were implemented. Essential library activities were computerized.

PROJECTIONS: During 1987-88, a Sydney automated library system will be purchased and installed. Efficient library services will continue. A secondary high-use storage area will be established. Training sessions will be held for library users.

FP-97 ADMINISTRATION, FINANCIAL AND ENGINEERING SERVICES

PROJECT STAFF: (GLFC)

OBJECTIVES: *To provide effective and efficient administrative and financial services in support of FPMI's program; to provide adequate physical facilities within which the Forest Pest Management's R&D program can be carried out and to ensure that these are operated and maintained in the most efficient and effective manner.*

ACHIEVEMENTS: The common support concept initiated in 1978 continues to meet its initial objectives. Continuous upgrading of equipment utilized by support personnel and the computerization of some of its functions has helped to maintain a high level of quality and quantity outputs in support of all programs.

During 1986-87, Phase III of the major construction program was completed. The Cameron Building was demolished in the fall of 1986 and landscaping was carried out. The septic system at the FPMI hangar was replaced and a new well was drilled and installed

PROJECTIONS: During 1987-88, the administration, financial and engineering units will continue to function in an effective manner.

Appendices

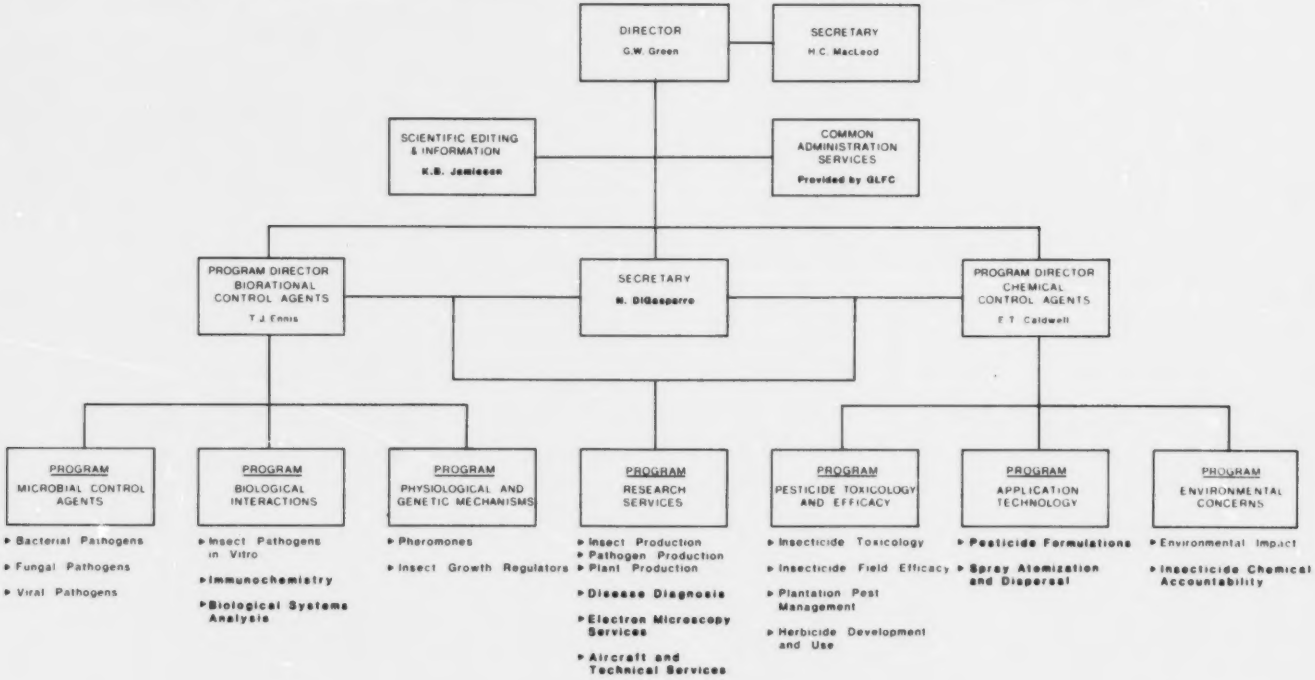
FOREST PEST MANAGEMENT INSTITUTE
EXPENDITURES 1986-87
($000's)

PROGRAM AREA	PERSON YEARS	SALARIES	OPERATIONS & MAINTENANCE	CAPITAL	TOTAL
Management	5.0	235.5	59.6	6.7	301.8
Finance and Administration	-	-	254.6	67.0	321.6
Physical Plant	-	-	236.5	140.9	377.4
Sci. Editing & Information	2.0	65.5	60.8	5.7	132.0
Library	-	-	65.1	-	65.1
Complementary Services	11.0	320.3	53.6	312.4	686.3
Microbial Control Agents	17.0	700.7	111.7	48.9	861.3
Biological Interactions	10.0	408.5	26.8	76 8	512.1
Physiological Mechanisms	6.0	235.1	32.2	24.1	291.4
Pesticide Toxicology & Efficacy	17.0	673.3	117.1	121.4	911.8
Application Technology	6.0	241.2	31.0	13.1	285.3
Environmental Concerns	9.0	341.3	47.9	74.7	463.9
TOTAL:	83.0	3,221.4	1,096.9	891.7	5,210.0

FOREST PEST MANAGEMENT INSTITUTE
RESEARCH AND DEVELOPMENT CONTRACTS 1986-87

Contractor	Title	Amount ($)	Scientific Authority
	1. From A-Base O&M		
H. Falter, Laurentian University	Effect of insect gut proteases on crystals and protoxin of *B.t.*	4,233	P. Fast (FP-10)
H. Kaplan, University of Ottawa	Definition of the location of disulphide bonds in the endotoxin of *B.t.*	4,900	P. Fast (FP-10)
	Subtotal (A-Base R&D Contracts)	9,133	
	2. PRUF Contracts		
K. Slessor, Simon Fraser University	Synthesis of high purity semiochemicals for cone & seed insect pests	11,895	G.G. Grant (FP-30)
G.A. Surgeoner, University of Guelph	Evaluation of the toxicity of Dimilin to non-target stream invertebrates	42,760	P.D. Kingsbury (FP-70)
P.J. Krell, University of Guelph	Viral DNA replication & genetic engineering of spruce budworm NPV	41,055	B.M. Arif (FP-13)
J. Picot, University of New Brunswick	Characterization of selected atomizers for use in insecticide & herbicide applications	15,977	N. Payne (FP-62)
H. Falter, Laurentian University	The role of activation in the toxicity spectrum of *B.t.*	29,580	P. Fast (FP-10)
D.N. Roy, University of Toronto	Development of analytical methodology and determination of leachability, persistence and lateral movement of Roundup in selected soils	3,386	D. Thompson (FP-54)
D.N. Roy, University of Toronto	Persistence and translocation of Roundup in competing vegetation during aerial spraying of boreal forests	8,035	D. Thompson (FP-54)
D.N. Roy, University of Toronto	Persistence, movement and degradation of Velpar in selected boreal forest soils	8,648	D. Thompson (FP-54)
	Subtotal (PRUF Contracts)	161,336	

FOREST PEST MANAGEMENT INSTITUTE - PROGRAM ORGANIZATION



FOREST PEST MANAGEMENT INSTITUTE
ORGANIZATION & STAFF LISTING
(As of 31 March, 1986)

Director	Dr. G.W. Green Secretary: H.C. MacLeod
Program Directors	Dr. T.J. Ennis Deputy Director
	Mr. E.T.N. Caldwell
	Secretary: N.J. DiGasparro
Administrative Officer	M.J. Parent Great Lakes Forestry Centre
Scientific Editing	K.B. Jamieson, Editor S. Stitt

RESEARCH & DEVELOPMENT PROJECTS

MICROBIAL CONTROL AGENTS

Program Director: Dr. T.J. Ennis

Project No.	Title	Scientific Staff	Technical Staff
FP-10	Bacterial Pathogens	Dr. P.G. Fast (Project Leader) K. van Frankenhuyzen	R. Milne C. Nystrom
FP-11	Fungal Pathogens	Dr. D. Tyrrell (Project Leader)	K. Humphries M. Welton C. Budau
FP-12	Protozoan Pathogens	Dr. G.G. Wilson (Project Leader)	E. Young

Program Director: Dr. T.J. Ennis

Project No.	Title	Scientific Staff	Technical Staff
FP-13	Viral Pathogens	Dr. J.C. Cunningham (Project Leader) Dr. B.M. Arif Dr. W.J. Kaupp Mr. P.B. Jamieson	B. Cunningham K. Brown R. Burke

BIOLOGICAL INTERACTIONS

Program Director: Dr. T.J. Ennis

FP-20	Insect Pathogens *in vitro*	Dr. S.S. Sohi (Project Leader)	G. Caputo B. Cook
FP-21	Cellular Interactions	W. Kaupp (Acting Project Leader)	J.A. MacDonald D. Nicholson
FP-22	Immunochemistry	Dr. A. Pang (Project Leader)	B. Mathieson
FP-23	Biological Systems Analysis	Dr. R.A. Fleming (Project Leader)	T. Burns

PHYSIOLOGICAL & GENETIC MECHANISMS

Program Director: Dr. T.J. Ennis

FP-30	Insect Pheromones	Dr. G.G. Grant (Project Leader)	D. Frech Vacant
FP-31	Insect Growth Regulators	Dr. A. Retnakaran (Project Leader)	L.F. Smith W. Tomkins

PESTICIDE TOXICOLOGY AND EFFICACY

Program Director: Mr. E.T.N. Caldwell

FP-50	Insecticide Toxicology	Dr. B.V. Helson (Project Leader)	D. Comba J. McFarlane

Program Director: Mr. E.T.N. Caldwell

Project No.	Title	Scientific Staff	Technical Staff
FP-51	Insecticide Field Efficacy	Mr. B.L. Cadogan (Project Leader)	P. Ebling B. Zylstra
FP-52	Plantation Pest Management	Dr. J. Turgeon (Project Leader) Mr. P. de Groot	N. Nelson A. Obarymskyj
FP-54	Herbicide Development and Use	Dr. P. Reynolds (Project Leader) Dr. R. Prasad Mr. D. Thompson	D. Pitt D. Travnick L. MacDonald B. Staznick

APPLICATION TECHNOLOGY

Program Director: Mr. E.T.N. Caldwell

FP-61	Pesticide Formulations	Dr. A. Sundaram (Project Leader)	J. Leung
FP-62	Pesticide Atomization & Dispersal	Dr. N. Payne (Project Leader)	J. Beveridge A. Robinson Vacant Engineer

ENVIRONMENTAL CONCERNS

Program Director: Mr. E.T.N. Caldwell

FP-70	Environmental Impact	Mr. P.D. Kingsbury (Project Leader) Mr. K. Barber Mr. S. Holmes Ms. R. Millikin	D.P. Kreutzweiser K. Mortensen
FP-71	Insecticide Chemical Accountability	Dr. K.M.S. Sundaram (Project Leader)	J. Broks R. Nott

COMPLEMENTARY SERVICES

Program Directors: Dr. T.J. Ennis
Mr. E.T.N. Caldwell

Project No.	Title	Scientific Staff	Technical Staff
FP-40-1	Insect Production	Mr. D. Grisdale (Study Leader)	A. McMorran K. Barratt L. Harwood H. Lauzon S. White
FP-40-2	Pathogen Production	Mr. J. McPhee (Study Leader)	H. Wigney
FP-40-4	Greenhouse Services	Mr. D. Buckley (Study Leader)	S. MacLeod

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